



Power from knowledge

## STANDARD OPERATION PROCEDURE FOR

### **TURBINE START UP (COLD /WARM /HOT / VERY HOT)**

SOP No	Revision	Date	Remarks / Reason for Revision
SWPL/OPRN/Critical / SOP- 06	0	11-Aug-2015	
	1		

AGENCY:

	Prepared By : Agency Engineer	Site	Reviewed/Cleared By : Agency Site Head	Validated by : Agency HO
Name				
Signature				
Designation				

### OWNER

	Reviewed by : EIC (Owner)	Reviewed &/ Approved by : Operation Head	Reviewed & Approved by: Plant Head	Reviewed & Approved By : Functional Head (HO)	Approved By : Apex Body
Name					
Signature					
Designation					



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**1.0 OBJECTIVE -**

Creating a Standard Operating Procedure (SOP), for ensuring smooth and safe startup operation of 4 Nos. Turbo-Generator (4\*135 MW) of SWPL.

**2.0 SCOPE –**

The contents of this SOP can be applied in SWPL Turbine start ups.

<b>List of Reference Documents</b>		
Sr.No.	Description of Document	Reference No.
1)	SWPL turbine Operation Manual	SCCTI-WI-CP-TOI

**3.0 SYSTEM DESCRIPTION:**

- 3.1 Dongfang Steam Turbine Works has supplied the 135 MW (Rated output) Steam turbine (Model-N135-13.73/537/537) and generator. The steam turbine is a condensing unit of ultra-high pressure, once reheat, single axle twin-cylinder and double flow. The Main steam flows through stop valves and a control valves fixed on both sides of unit into the HP turbine. The flow is reverse in high pressure section. The cold reheat steam which exits the HP turbine is reheated and flows as Hot Reheat steam into the IP turbine through a combination of stop valve and control valves fixed on both sides of unit. The IP turbine exhausts through the LP turbine into the condenser. The exhaust of the LP turbine is condensed in the condenser. During start up and shutdown the Desuperheated bypass steam is dumped into condenser via a HP bypass control valve & a LP bypass control valve.
- 3.2 Number of stages: HP – 1+8 Nos. IP – 10 Nos., LP – 2X6 Nos. The total number of stages is 31.
- 3.3 Rated steam conditions:
- 4.3.1 HP steam pressure & temperature: 13.73 Mpa & 537 °C
  - 4.3.2 HRH steam pressure & temperature: 2.304 Mpa & 537 °C
  - 4.3.3 LP steam pressure & temperature: 0.24Mpa & 244.3 °C



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3.4 Steam turbine has the following auxiliaries:

3.4.1 Lube oil system, DEH Oil system, Vacuum creation system, Cooling water system, Condenser and its make up system, Turbine drains and gland sealing system, Generator cooling system, Instrument air system, HP & LP bypass system, Boiler Feed water system

**4.0 Never start or synchronize the unit in case of any one of the following conditions:**

**(DON'Ts)**

- 4.1 Work (installation, maintenance, testing) on the unit has not been finished and the permit-to-work has not been cancelled.
- 4.2 The main interlocks and protections of the unit fail to pass test or their settings are not in accordance with requirements.
- 4.3 Malfunction of any one protection device
- 4.4 Malfunction of main regulating device
- 4.5 Failure of self-operated control device, affecting the unit start-up or normal operation.
- 4.6 Loss of supervisory C&I, excessive unit parameter value
- 4.7 Power failure for C&I and protection devices
- 4.8 Failure of DCS communication or failure of any process control unit
- 4.9 Abnormal condition with control systems such as DEH, FSSS, SCS and CCS.
- 4.10 Abnormal condition with service and instrument compressed air systems.
- 4.11 Any one of turbine HP/IP MSV, CV, RSV, ICV, extraction check and HP exhaust check valves is jammed or fails to close fully, or HP casing VV fails to operate normally.
- 4.12 Malfunction of drum level gauges on both sides
- 4.13 Quality of steam or feed water is not up to standard.
- 4.14 Turbine shaft eccentricity is 0.03mm greater than its original value.
- 4.15 Rubbing of the rotating part is heard when the turbo-generator set put on turning gear.
- 4.16 Turbine lube oil tank level falls below the limit or the oil quality is poor.
- 4.17 EH oil tank level is low or the oil quality fails to measure up.
- 4.18 Temperature difference between any two points on upper and lower HP/IP cylinder half exceeds 80Deg cent
- 4.19 Malfunction of turbine emergency governor
- 4.20 Generator stator/rotor winding insulation unqualified.
- 4.21 By-pass system fails, forbidding hot start-up of the unit.
- 4.22 Failure of AC lube oil pump or DC emergency oil pump, or their interlocks and protections fail to pass testing.

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- 4.23 Diesel-engine generator fails to pass loading test.
- 4.24 UPS is not in readiness for service.
- 4.25 Abnormal condition with auxiliary power service
- 4.26 26)Other defects or abnormal conditions endangering the safely of the unit startup

## 5.0 PRE-REQUISITES

### 5.1 Mechanical

- 5.1.1 All the above auxiliary systems should be checked and kept ready as per their standard procedure.
- 5.1.2 Ensure instrument air compressor is running with min. pressure of 7 bars.
- 5.1.3 Ensure CCW system is in service for all the coolers.
- 5.1.4 The level of MOT &DEH oil tank to be normal
- 5.1.5 Start AOP manually and check for all the bearing return oil flow.
- 5.1.6 Check that the HP DEH oil and HP&LPBP controller oil pressure is within operating parameter.
- 5.1.7 Check for any leakages in lube oil header & pressure should be approx. 0.15 ~0.18 MPa.
- 5.1.8 Test the DC EOP and record its oil pressure. Place the selector switch in “AUTO”.
- 5.1.9 Switch off the AOP and check for auto pick up of EOP in “Auto”.
- 5.1.10 The vapour extraction fan on the lube oil tank should be running & Stand by fan should be in AUTO
- 5.1.11 The AC Jacking oil pump is running and stand by pump is in AUTO.
- 5.1.12 The BFP is running and stand by pump is in AUTO
- 5.1.13 The CCW Pump is running &stand by pump is in AUTO
- 5.1.14 The CWPS are running & stand by pump is in AUTO
- 5.1.15 Check the seal water availability to the vacuum pumps.
- 5.1.16 Ensure STG turning gear is in “AUTO”.
- 5.1.17 The hot well should be filled up to optimum level.
- 5.1.18 The CEP is running and stand by pump is in “AUTO”.
- 5.1.19 Line up the gland steam system with the exhaust fans in “AUTO”.
- 5.1.20 The LP gland steam desuperheating control valve should be in “AUTO”
- 5.1.21 All steam turbine drains should be in “AUTO” and in open position.
- 5.1.22 The control valve for de-superheating HP & IP drains should be in “AUTO”.
- 5.1.23 The HP, IP & LP by pass valves should be kept in “Auto” with their de-superheating system in “AUTO”.
- 5.1.24 Exhaust Hood spray valve should be in “AUTO”.

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5.1.25 Ensure water seal in the vacuum breaker of condenser.

#### **5.2 Electrical**

- 5.2.1 Ensure T G MCC charged from Station switch gear ..
- 5.2.2 The steam turbine generator transformer should be ready for service.
- 5.2.3 110 / 240 / 415 V AC power should be available.
- 5.2.4 Control Power supply 220V DC should be available and normal.
- 5.2.5 Ensure UPS is in service.
- 5.2.6 Battery Charger should be in service and charger voltage should be normal.
- 5.2.7 All Generator protection relays should be healthy.
- 5.2.8 Clearance from the LDC side before synchronisation should be obtained.

#### **5.3 C & I**

- 5.3.1 Ensure all local gauges, transmitters and switches are calibrated, fixed and lined up.
- 5.3.2 Ensure all the interlocks and permissive have been tested and kept ready.
- 5.3.3 Check and ensure healthiness of the following major supervisory instruments.
  - i. Eccentricity limits,
  - ii. Rotor position limits,
  - iii. Vibration pick-ups & limits,
  - iv. Differential expansion.

- 5.3.4 Steam Turbine status should be ready to start.
- 5.3.5 Ensure the Over Speed Protection Controller is tested and in service.
- 5.3.6 Mechanical and Electrical Over speed protection is tested and in service.
- 5.3.7 Ensure all the indications are available and healthy on the OIS.

#### **5.4 Others:**

All the departments C&I, Mech, Elect should have given clearance for start up.

#### **6.0 SAFETY CHECKS:**

- 6.1 All Work permits have been cancelled & Men and Materials have been cleared.
- 6.2 CO2 system for firefighting is ready and in AUTO mode.
- 6.3 Firefighting system (deluge etc.) is ready for the steam turbine, transformer and Main lube oil tank.
- 6.4 PPE should be worn in local area during the bypass operation (ear muffs).
- 6.5 All the steam turbine auto protections are in service, as they take care for men & machine (e.g. over speed protection).

#### **7.0 ENVIRONMENTAL CHECKS:**

- 7.1 During Start up the Bypass operation will generate sound for the duration of bypass valves being open. Care to be taken by using PPE for the same.



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7.2 In case of water / steam leak it is to be immediately isolated or system stopped in case it becomes larger.

## **8.0 START UP PROCEDURE:**

### **8.1 Turning operation**

- 8.1.1 Ensure the lube oil system in service.
- 8.1.2 Check the lube oil pressure at the turning gear it should be approx. 0.1 MPa.
- 8.1.3 Give the turning start command from the CRT.

### **8.2 Limits for startup and operation of the unit**

- i. The steam turbo-generator and auxiliaries(bearing cap) vibration / Shaft vibration limit:

Steam turbo-generator ( $\mu\text{m}$ )	Excellent		Fine	Regular
	<20		< 30	< 50
Vibration limits of auxiliaries ( $\mu\text{m}$ )	1500 r/min below		1500 r/min above	
	< 80		< 50	
Name	Unit	Normal value	Alarm value	Shutdown value
Control value for bearing vibration	mm	$\leq 0.03$	0.05	0.08
Shaft vibration (peak-peak value)	mm	$\leq 0.076$	0.125	0.25

- ii. Shaft gland system

Name	Unit	Normal value	High alarm	Low alarm
Gland steam manifold pressure	MPa	0.12	0.25	0.1
LP gland seal steam temperature	°C	150	260	120
Gland heater vacuum	KPa	-5		
Gland heater water level	mm	150	200	120

- iii. The relative expansion of turbine

Name	Unit	Normal value	Alarm value	Shutdown value
axial displacement	mm	0	+0.6 / -1.05	+1.2 / -1.65
HP/IP Differential expansion	mm	<+6	+6.0 / -3.0	+6.2 / -3.2
Low differential expansion	mm	<+6	+7.0 / -6.0	+7.2 / -6.2

- iv. Control data of deaerator operation

Item	Unit	Normal value	High alarm	Low alarm	Remark
Deaerator water level	mm	2250	2450	2050	



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Deaerator pressure	MPa	Sliding pressure			
Deaerator temperature	°C	167			
Working value of safety valve	MPa	Working value of Water tank safety valve:0.8MPa, Working value of Deaerator safety valve:0.85MPa			

## v. Lubrication oil system of turbine:

Name	Unit	Normal value	High alarm	Low alarm	Shutdown value
Lubrication oil pressure Automatically start up AC lubricating, oil pump= 0.049 Automatically start up DC lubricating, oil pump= 0.039 Value for stopping turning gear = 0.03	MPa	0.08~0.15		0.049	0.039
Inlet oil pressure of main oil pump	MPa	0.08~0.15			
Outlet oil pressure of main oil pump	MPa	1.8±0.05	1.85	1.75	
Outlet oil temperature of oil cooler	°C	38~45	46	38	
Bearing scavenge oil temperature	°C	<65			75 shutdown
Metal temperature of supporting bearing	°C	<90			115 shutdown
Thrust pad temperature	°C	<90			110 shutdown
Main oil tank level	mm	1550	1750	1350	
Control range of heater	°C	20~35			
Exhaust steam temperature of LP casing	°C		80°C		120 °C
Axial Displacement the movement of rotor toward generator is plus, the opposite is minus)	mm		+0.6 - 1.05mm		+1.2 -1.65mm
Condenser pressure	MPa	0.009		>0.0147	0.0196

**8.3 VARIOUS STARTUPs**

Based on the metal temperature of inner wall at regulating stage of upper HP inner casing half, turbine start up falls into one of the following four modes:



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State	Shutdown time	Governing stage cylinder temperature	Start-up parameter	Rising speed	Loading rate
Cold state	More than 72hrs	<150°C	1.0 MPa , Main Steam Temp.270°C & RH temp 230°C	100r/min/min	1MW/min
Warm state	10~72h above	150~300°C	1.6MPa,main steam temperature 400±10°C,reheat steam temperature 300°C above	150r/min/min	3MW/min
Hot state	10h	300~400°C	3.6MPa,main steam temperature 440±10°C,reheat steam temperature 410°C	200r/min/min	4MW/min
Top hot state	1h	400°C above	4.5MPa,main steam temperature 510±10°C,reheat steam temperature 480°C	300r/min/min	6MW/min

### 8.3.1 COLD START UP

- 8.3.1.1 Close vacuum breaker valve, start vacuum pump and gland steam condenser fan to create vacuum, confirm that there is no water in gland seal steam pipeline, then supply steam to each gland pipes, keeping gland steam header pressure at 0.123MPa (Abs), temperature shall be at 120to180 °C
- 8.3.1.2 Check that drain valves on main and reheat steam pipes are open and that drain valves on casing are open.
- 8.3.1.3 When vacuum increases to 70KPa, check that no trip signal is initiated. After given permission, push the button “LATCH” on DEH menu to latch turbine. Then push the button “PREWARM” to perform pre-warming of HP casing and MSV/CV shells, and apply cylinder interlayer heating as needed.



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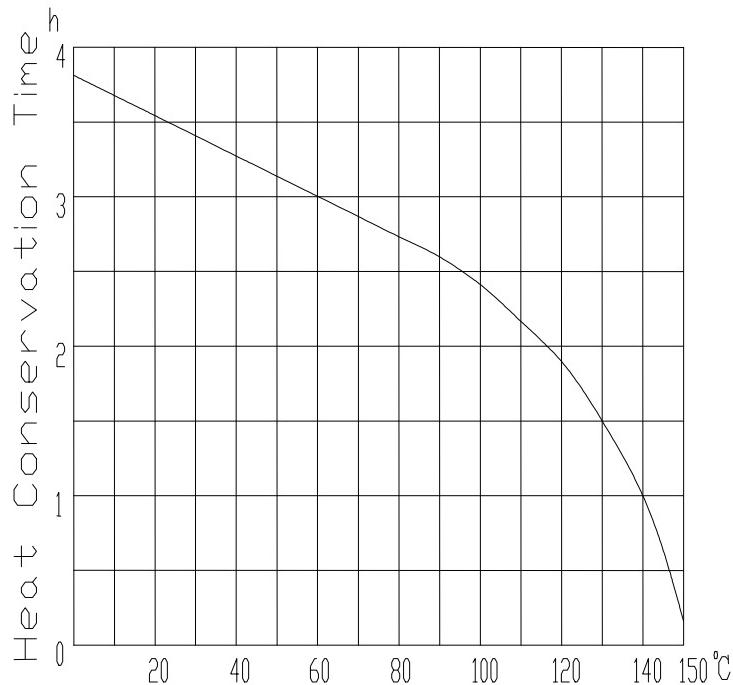
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Fig-1 HP Inner casing Pre Warming



Metal Temperature of Upper Half of Inner Wall at regulating

### Stage of HP Inner Casing before Pre-warming

8.3.1.4 HP casing pre-warming conditions is: P=0.4to0.8 MPa, T=200 to 250Deg cent, with degree of superheat maintained above 50deg. As casing being warmed, the rate of temperature rise shall be kept less than 50Deg/h, keep the pressure inside HP casing at 0.4to0.5 MPa by adjusting the RFV and drain valves casing differential temperatures and differential expansion within the permissible range. When governing stage inner wall metal temperature of upper HP inner half casing increases up to 150deg cent, keep on preheating for one hour. then the casing pre-warming is finished

#### 8.3.1.5 steam parameter for turbine Rolling

Main steam pressure	1.0 MPa
Main steam temperature	280 °C ± 10deg °C
Reheat steam temperature	220 °C

8.3.1.6 Check the steam turbine casing expansion, differential expansion, axial shift, rotor eccentricity, bearing metal temperature, bearing drain oil temperature.

8.3.1.7 Normal operation limits:



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- a. Rotor eccentricity: less than 0.05 mm
- b. Casing expansion: less than 25 mm
- c. Differential expansion: 1.5 mm
- d. Rotor position (Axial shift): 0.4 mm

8.3.1.8 Verify LP exhaust hood spray CV (CD-AOV-0017) on ‘AUTO’ and is in closed condition.

Verify that all turbine drain valves are in ‘AUTO’ and are in opened position.

8.3.1.9 Steam Turbine Start

8.3.1.10 **FRiction CHECK** is recommended for every cold start up. It can be avoided when shut down is for a short period and no maintenance is performed on the steam turbine.

- Select “SPEED TARGET” – “500”.
- Select “ACCELERATION RATE” – “100”.
- Select “PROGRAM OPERATION” – “GO”
- The HP &IP regulating valves will open.
- Observe for speed rise. Check for no abnormality on
  - Eccentricity
  - Axial Shift
  - Shaft Vibrations
  - Bearing temperature
  - Bearing Drain oil temperature etc.
- Observe that the speed of the steam turbine starts to increase.
- Check that the turning gear gets disengaged and the motor is automatically stopped.
- Verify the speed is stabilised at 500 rpm.
- Select “(Close all valves) on the CRT and verify that all CV’s and HP stop valves are closed.
- Ensure no abnormal sound / noise is heard at the steam turbine seals. And speed does not come to zero rpm before 5 minutes.



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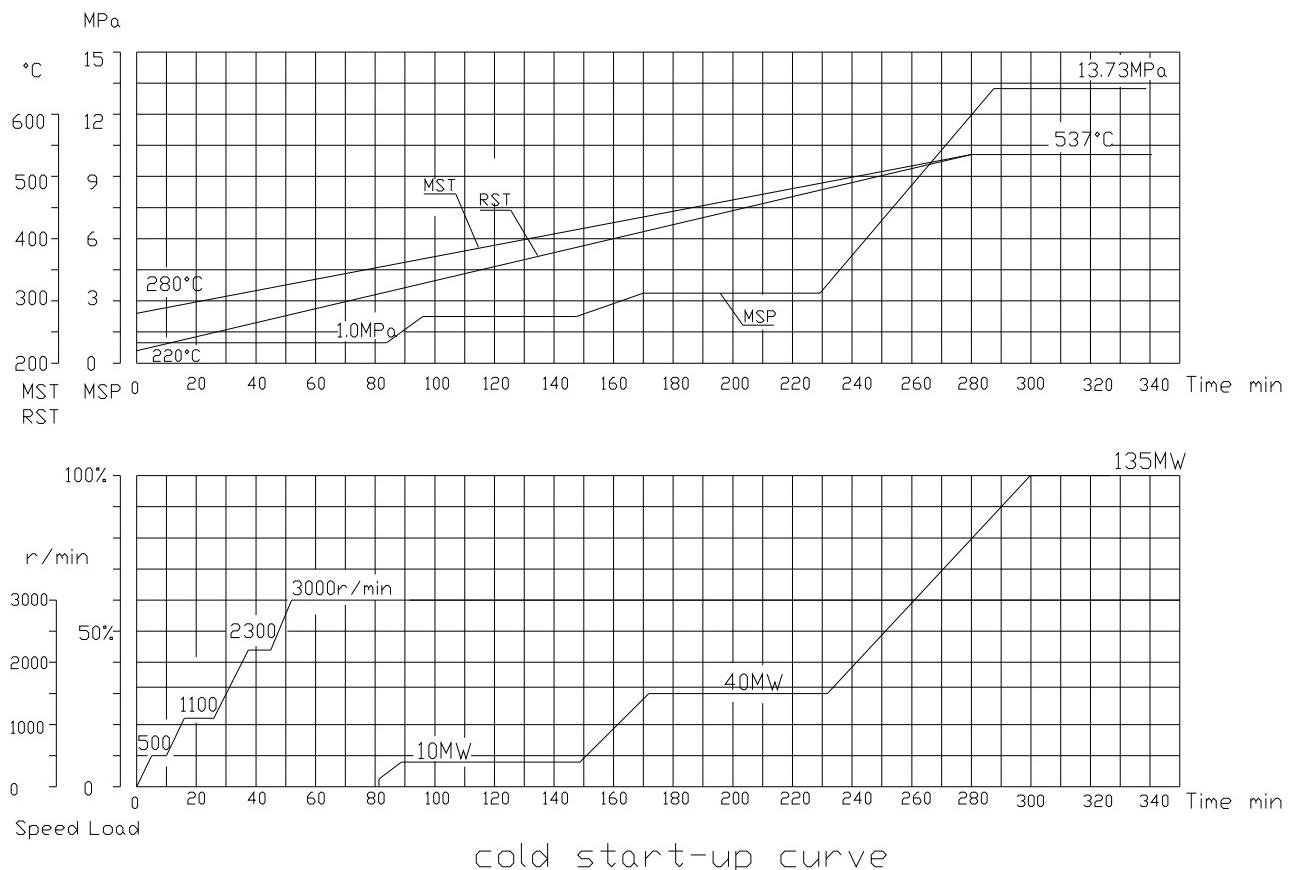
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Fig-2 Cold start-up curve



**8.3.1.11 After FRICTION CHECK - "RESET" the steam turbine on confirmation of rub check found**

- OK.

- Select "SPEED TARGET" – "1100".
- Select "ACCELERATION RATE" – "100".
- Select "PROGRAM OPERATION" – "GO". HP Control opens and admits the steam.
- Observe for speed rise at the pre-selected rate and 1100 rpm is achieved.
- Warm up the turbine at this speed for 10 min
- Continue to check for the normal operating parameters such as
  - Eccentricity
  - Axial Shift
  - Shaft Vibrations
  - Bearing temperature
  - Bearing Drain oil temperature
  - Casing expansion,
  - Differential expansion,



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- Axial shift etc.

- If no abnormality in parameters is observed raise the speed.
- Select “SPEED TARGET” – “2300”.
- Select “ACCELERATION RATE” – “150”.
- Select “PROGRAM OPERATION” – “GO”. Verify the Control valve becomes open some more. Observe the speed rises and holds at 2300rpm.
- Stop operation of Jacking oil pump in auto when speed >1200 rpm
- During rise in speed observe the Steam Turbine parameters are to be maintained.
- Allow 10 minutes heat soaking of the turbine at 2300 rpm as per the control stage outlet metal temperature. See the HPExhaust temp at hp lower half inner casing is greater than (- -----)
- If no abnormality in parameters is observed raise the speed.
- Select “SPEED TARGET” – “3000”.
- Select “ACCELERATION RATE” – “150”.
- Select “PROGRAM OPERATION” – “IN”. Observe the speed rises and holds at 3000rpm.
- Perform no load warming up for 30 Min
- Observe increase in LP casing exhaust temp spray to be started Automaticaly when temp reaches >80 degcent
- During no-load warming at 3000 rpm, check that main oil pump and oil ejector work properly, with main oil pump outlet pressure within 1.372to2.05MPa. Then, stop AC lube oil pump to test whether main oil pump outlet and inlet pressure and lube oil pressure are stable. If not, make adjustment and then put the AC lube oil pump in standby position.
- After no-load warming at 3000rpm, carry out remote trip of turbine when condition permits, make sure that all the HP/IP MSV/CV/RSV/IV are closed fast and rotor speed drops drastically. Then latch turbine again, setting speed rise rate at 200~250 rpm/min, and run up to 3000 rpm steady operation.
- During steady operation of unit, perform the following tests as per the testing procedure of control & protection system.
  - ◆ Emergency governor oil injection test
  - ◆ HP trip protection module solenoid valve online test
  - ◆ **Over speed protection (OSP) solenoid valve online test**
  - ◆ Perform Electro hydraulic governor Lower and Upper limit test.
- At rated speed check all the operation parameters, especially vibration, bearing metal temperatures, bearing oil supply temperature / pressure, drain oil temperature, casing



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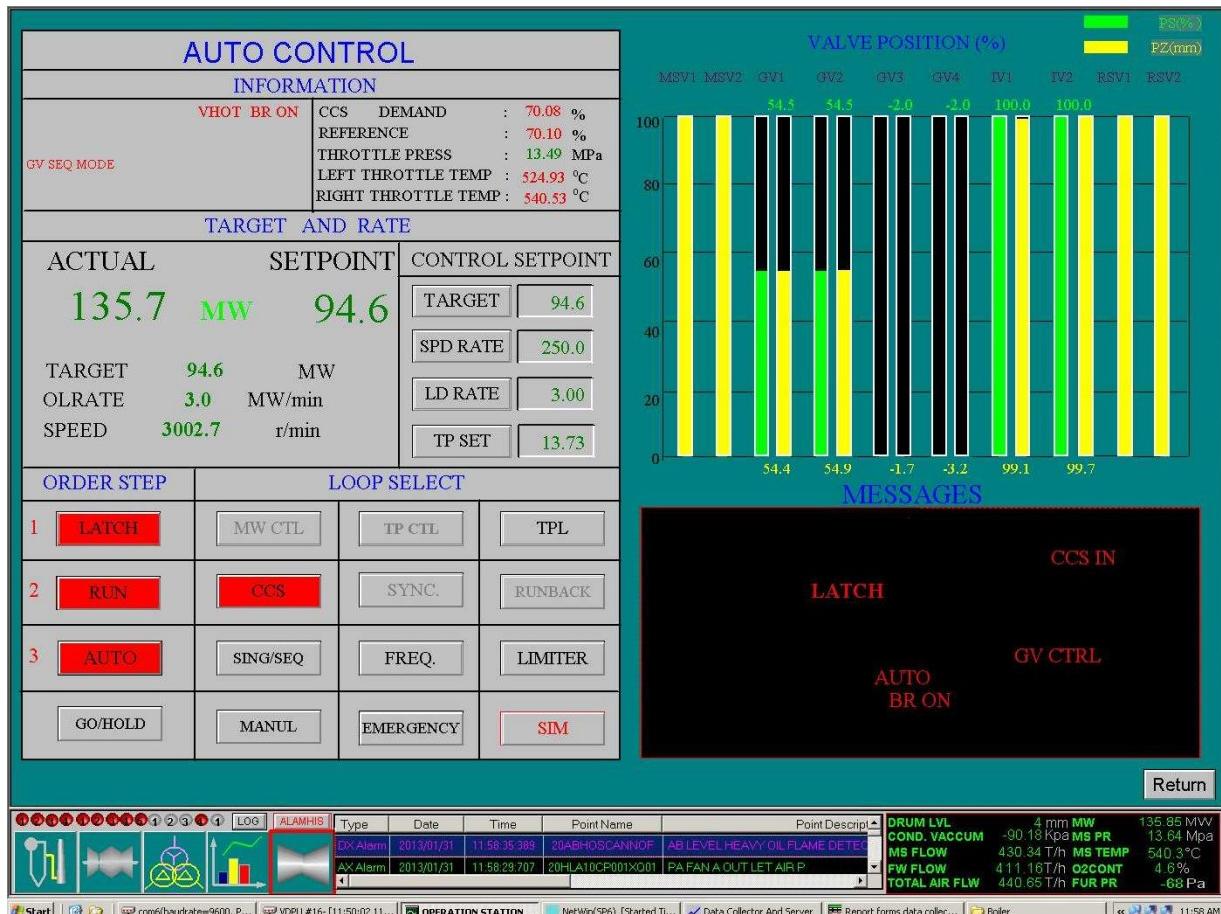
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expansion, differential expansion, rotor position (axial shift) etc.



### 8.3.1.12 SYNCHRONIZING

- Select the CB for synchronising operation from CCR. Verify CB 1 or 2 are in open position.
- Close the isolator no. 2 and check all three phases make good contact.
- Close the Field Circuit Breaker. Observe the generator voltage is built up to 13.8 kV.
- Put the AVR in “AUTO” from DCS.
- Check the grid voltage and adjust the ST transformer OLTC so as to match the grid voltage.
- Put the synchronizing selector switch to “AUTO” in DCS. Observe the frequency, voltage and the phase out indication bulbs.
- When the generator Frequency, Voltage and phase matches with that of the grid, the Generator CB is closed. (The synchroscope will be at 12’Oclock position.)
- As soon as CB is closed, block load of 5 MW is attained.
- In case of first start up and start up after long shut down, over speed test should be performed. Prior to over speed test it is to be ensured that the machine is heat soaked for at least 4 hrs with more than 20% load. Mechanical trip is set to actuate at less than 110+



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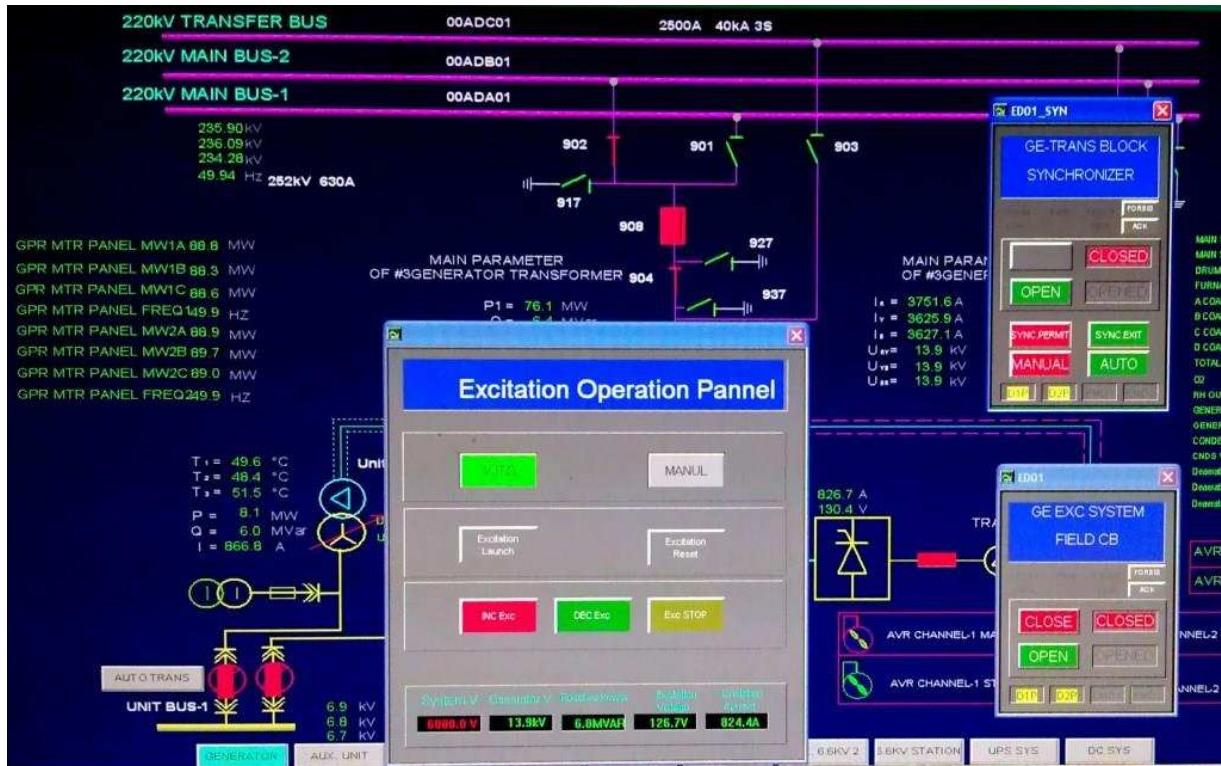
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0.5 / -1.0 % of rated speed i.e. 3300 rpm. Electrical trip is set at 112% of the speed i.e. 3360 rpm. From its 3300 rpm at the time of over speed testing.

- Perform the load rejection test in case of first start.



### 8.3.1.13 LOADING

- Verify that initial load holding time (i.e.10 minutes at 5MW) indicator shows zero. This is required in order to ensure uniform heat up of entire turbine and rotor.
- Continue to raise the pr &temp of boiler and load up the unit to rated load with1.3 Mw /min loading rate.
- When the load of unit reaches 15%,20%,25%of rated load , close drain valves at HP,IP,LPstages respectively.
- Transfer to Pressure Control mode:
- Select HP & IP pressure control “IN” on the DCS and check that HP, IP, turbine bypass valves start getting closed gradually while the pressure inlet to the turbine is regulated by the respective control valves. HP & IP Bypass valves are set to close from 0% to 100 % in approx. 20 minutes. On observation the IP Bypass Valve will close first (in approx 6 min.) & IP CV becomes 100% open, load on ST gradually rises to around 35.5 MW. HP CV becomes open 100 % and HP bypass valves closes in approx 32 min., ST load raises to 53.5 MW.
- Select LP pressure control “IN” on the DCS and check that the LP turbine bypass valve is



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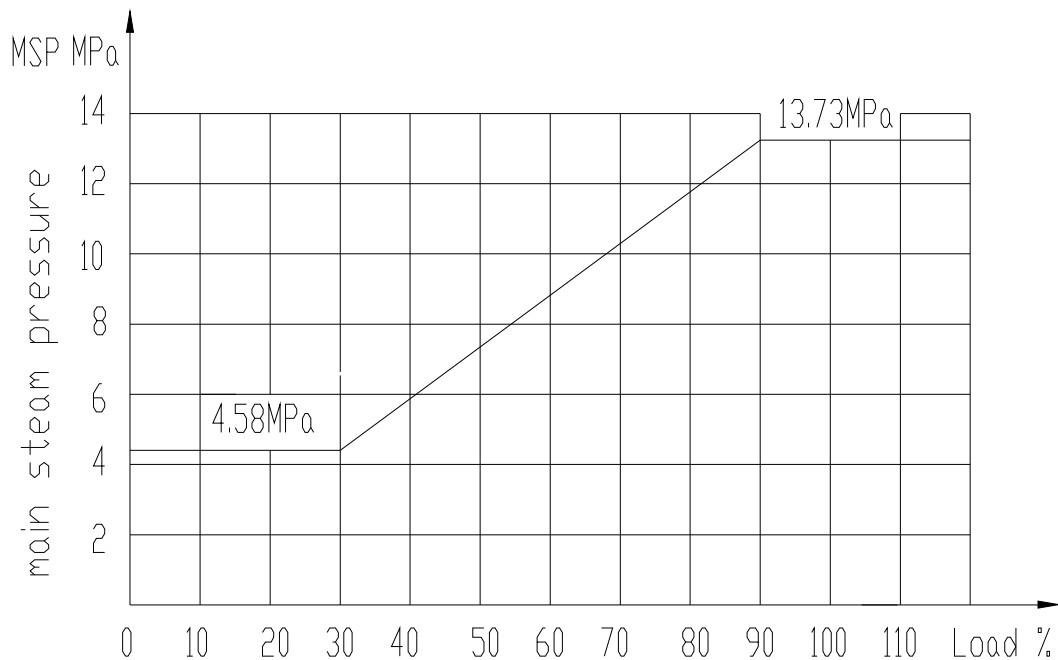
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closed gradually while the LP control valve regulates steam pressure inlet to the turbine.

During base load LPCV is approx 30% open.

- Sliding pressure
- The turbine is now on pressure control mode. As the GT load is raised the HP, IP & LP steam pressure rises and the Control valves open gradually to 100%. There after further rise in steam pressure causes the steam turbine load to rise as per rise in pressure of steam generated at HRSG.
- LP turbine exhaust hood spray valve closes at 10% load (10 MW).
- All turbine drain valves closes at 20% load (20 MW).

**Annex 1 Varying Curve of Sliding pressure operation**



Varying Curve of Slide Pressure Operation



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**8.3.2 WARM START UP**

After fulfilling prerequisite checks as per sec

- 8.3.2.1 Provide auxiliary steam to gland steam system before starting up of the unit. The pressure inside the main pipe of gland steam system should be 0.127Mpa and temperature should be 150deg~250deg.
- 8.3.2.2 Set up the vacuum in condenser after gland steam system being put into normal operation and the pressure of condenser is required to reach below 20Kpa.
- 8.3.2.3 Fully open each drain valve on each pipe and turbine.
- 8.3.2.4 Steam parameter for turbine start-up
  - a) Main steam pressure 1.6MPa
  - b) Main steam temperature 400Deg cent +- 10Deg cent
  - c) Reheat steam temperature 300Deg cent
- 8.3.2.5 Turning gear device should disengage out automatically after the unit being turned with steam. Otherwise, the unit should be manually shut down.
- 8.3.2.6 Speed up the unit with the rate of 150rpm up to rated speed after thorough checks for normality
- 8.3.2.7 After stabling of the speed if the exhaust steam temperature exceeds 80°, the water spraying device of LP casing should be put into automatically, otherwise the device should be manually operated. At this time, the pressure in condenser should not exceed 12KPa; otherwise the protection system for low vacuum should be put into.
- 8.3.2.8 Stop operation of jacking oil pump when the speed rises to 1200r/min

**8.3.2.9 LOADING**

- Automatically loading of 3%, rated load by the control system after synchronization, load up the unit to 13.5MW with 3MW/min loading rate according to the warm state sliding parameter start up curve. Keep warming up the unit for 20 min.
- Continuously load up the unit with 3MW/min loading rate to rated load.
- When the load of unit reaches 25% of rated load, close drain valves at each stage respectively.
- Put in and cut off the turbine interlayer heating device according to casing temperature and differential expansion
- Attention should be paid to monitoring temperature difference between the inner wall and outer wall of stop valve and control valve when starting up the unit, never heat



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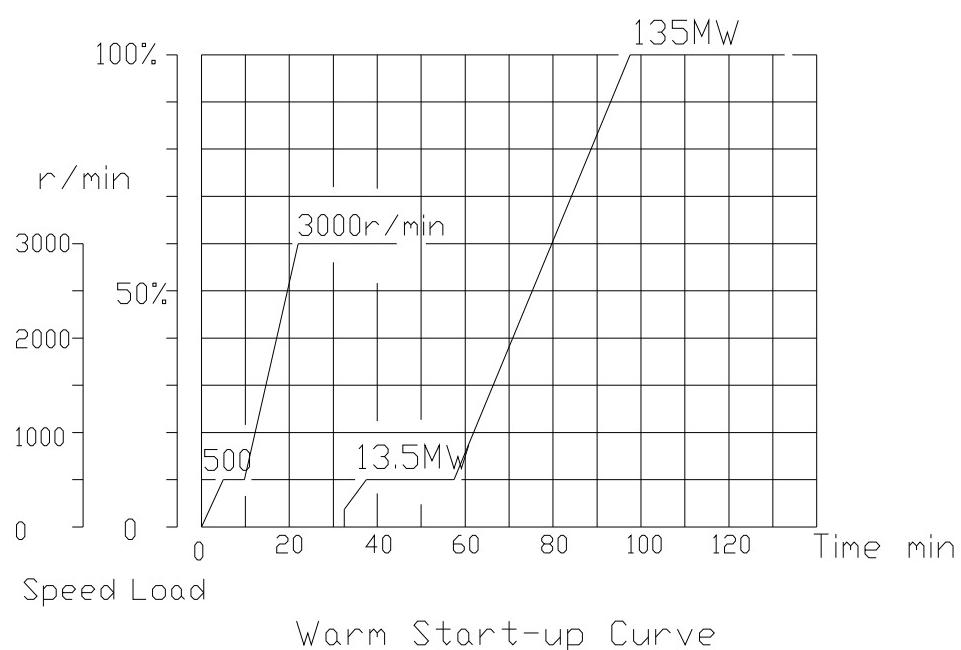
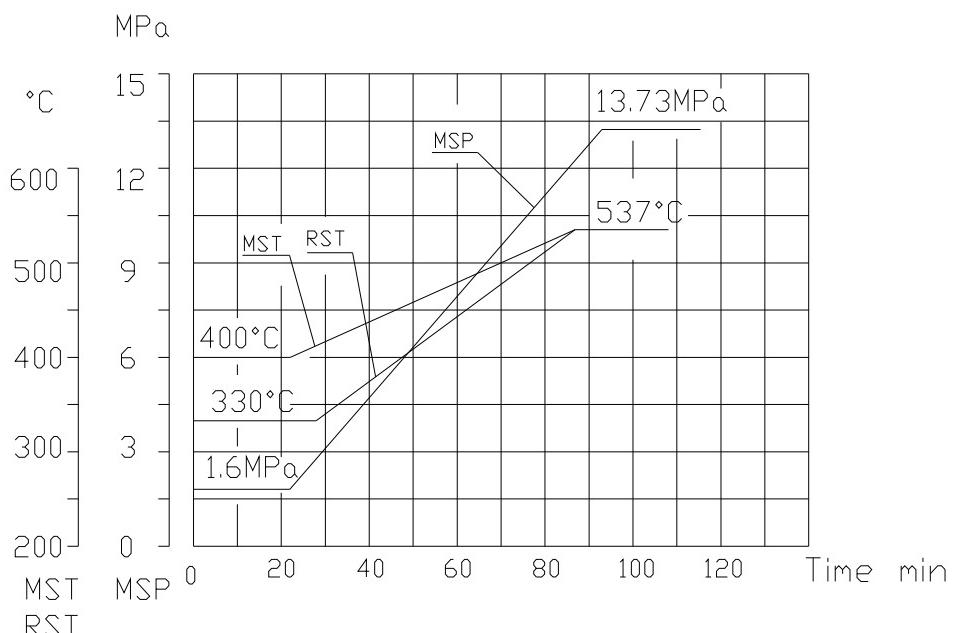
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them too fast, because their cooling down after shut down of the unit is quite fast

**Annex 3 Warm startup curve**



Warm Start-up Curve



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### **8.3.3 Hot &Very hot start up**

#### **8.3.3.1 After fulfilling pre requisite checks as per sec**

Gland steam auxiliary steam supply should be firstly put into operation before starting up of the unit, and then extract the vacuum. It is required that the pressure in gland steam main pipe is 0.127Mpa, temperature is from 250Deg cent to 350 Deg cent.

#### **8.3.3.2 Vacuum of the condenser should be set up after gland steam system being in normal operation, the pressure of the condenser should reach to below 20Kpa.**

#### **8.3.3.3 Fully open drain valves of each piping and turbine body.**

#### **8.3.3.4 Steam Parameters**

- ◆ Main steam pressure 3.6Mpa
- ◆ Main steam temperature 440Deg cent ±10Deg cent
- ◆ Reheat steam temperature 410Deg cent

#### **8.3.3.5 Very hot sliding parameter start up**

- ◆ Main steam pressure 4.5Mpa
- ◆ Main steam temperature 510Deg cent±10Deg cent
- ◆ Reheat steam temperature 480Deg cent

#### **8.3.3.6 When the speed of the unit reaches 500r/min, check whether there is friction between the rotor and static parts, whether the HP exhaust check valve is in full-open state. But the time stay at this speed should not exceed 5 min.**

#### **8.3.3.7 Speed up the unit to rated speed with the rate of 250rpm, after confirming that everything is normal. After the speed is stable, the pressure of condenser should not exceed 12Kpa, exhaust steam temperature should not exceed 80deg cent. The unit may be synchronized and carry load if nothing abnormal is found in the unit (stop jacking oil pump at the speed of 1200r/min).**

#### **8.3.3.8 LOADING**

After synchronization, smoothly load up the unit to rated load with 5MW/min loading rate according to hot sliding parameter start up curve. For very hot start-up, smoothly load up to rated load with 6MW/min loading rate according to very hot sliding parameter start up curve. Separately close drain valves of each stage when the load of the unit reaches 25% of rated load.

#### **8.3.3.9 Attention should be paid to monitoring temperature difference of inner wall and outer wall of main steam and regulating valve, never heat them too fast, because they cool down quite fast after unit shut down.**



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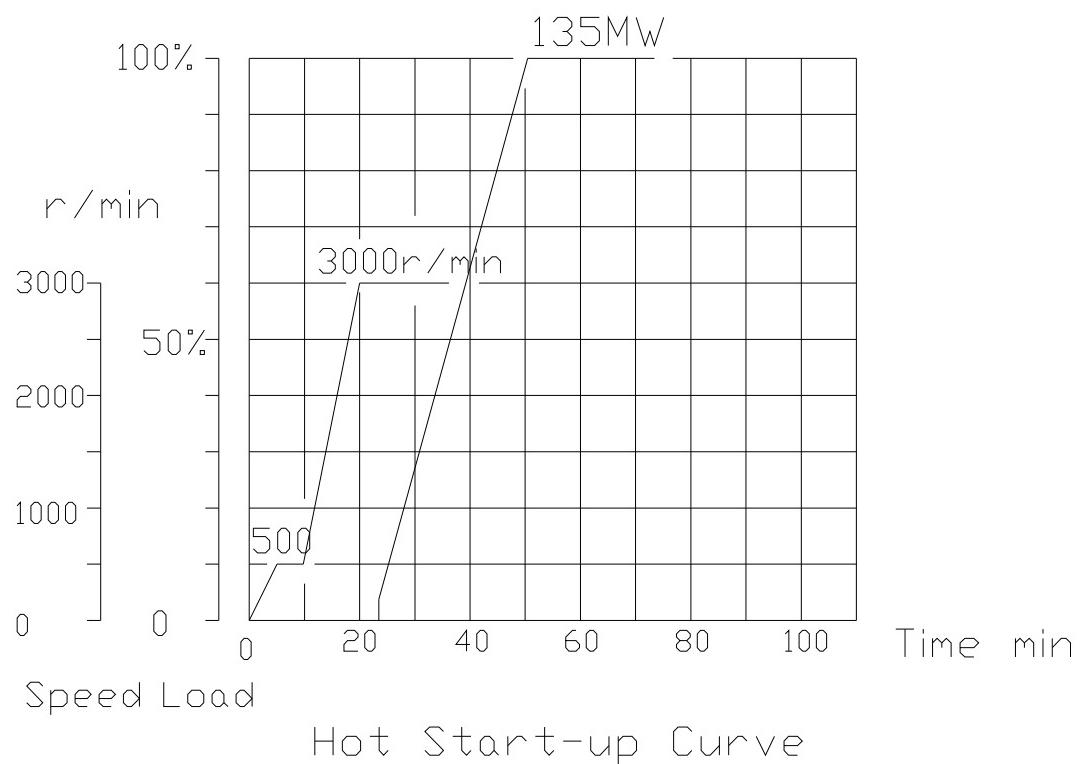
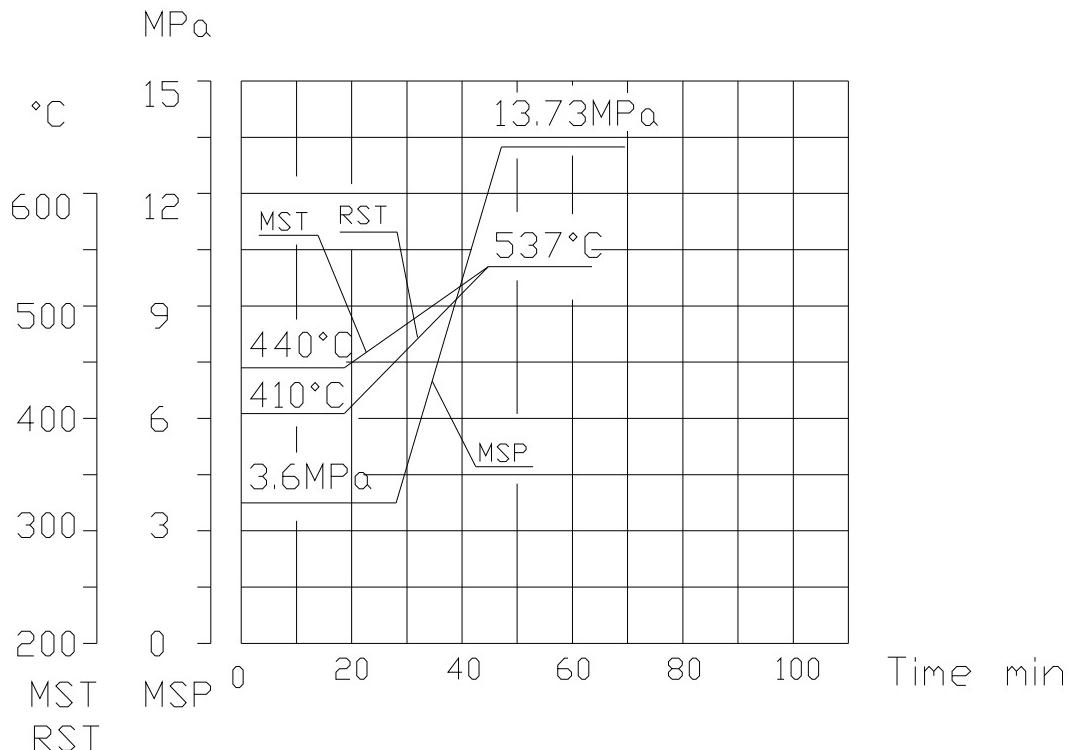
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## Annex 4 Hot startup curve





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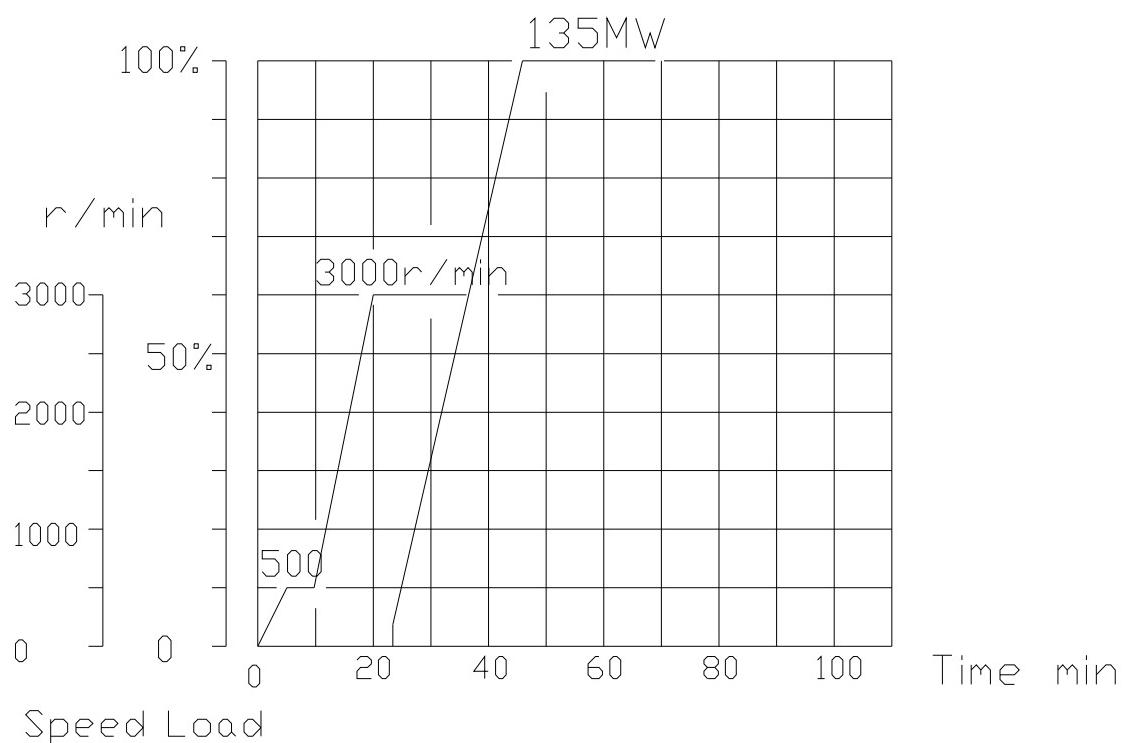
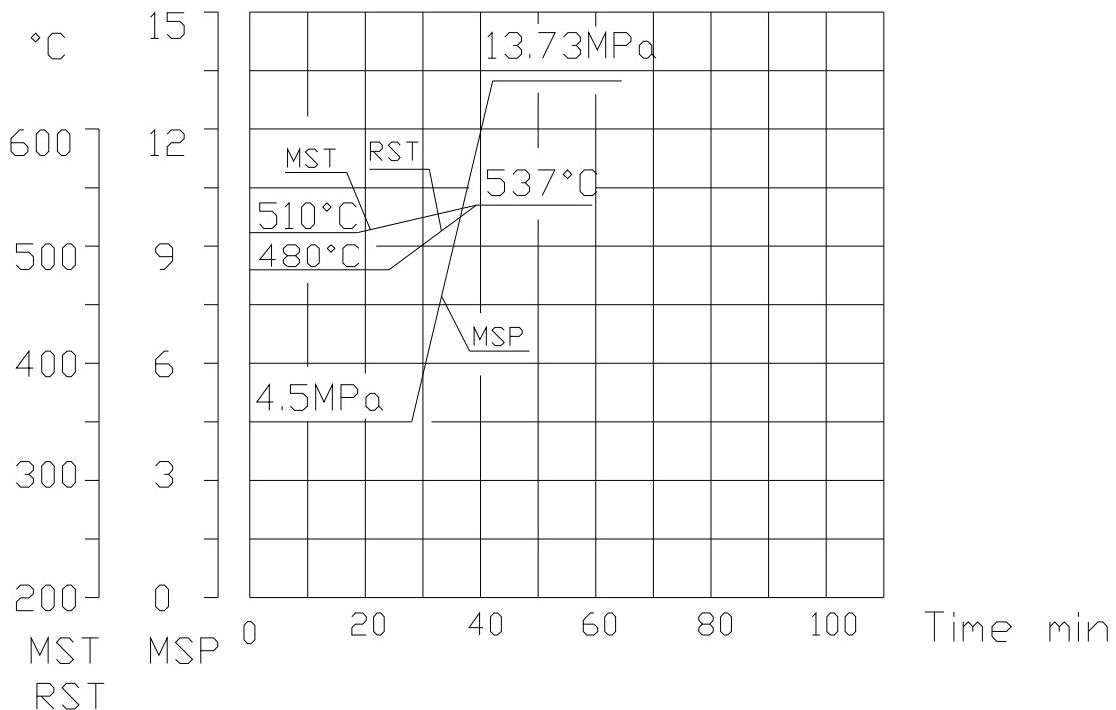
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**Annex 5 Very-hot startup curve**

MPa



Very Hot Start-up Curve



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## 9.0 NORMAL OPERATING PARAMETERS / ALARMS &amp; TRIP SETTING:

Sr. No.	Description	Normal	Alarm	Trip
1.	HP steam pressure	101.84 bar (a)	115 bar	117 bar
2.	IP steam pressure	35.33 bar (a)	40 bar	40.7 bar
3.	LP steam pressure	3.3 bar (a)	4.5 bar	5.0 bar
4.	HP steam temp.	537.7 °C		550 °C
5.	IP steam temp.	537.2 °C		550 °C
6.	LP steam temp.	137.2 °C		
7.	HP drum level Hi Hi			305 mm
8.	IP drum level Hi Hi			203 mm
9.	LP drum level Hi Hi			254 mm
10.	Condenser Vacuum	(-0.93 bar)	- 650 mm Hg (- 0.855 bar)	- 553 mm Hg (-0.733 bar)
11.	Brg. Lube oil pressure	1~ 1.8 bar	0.75 bar	0.5 bar
12.	Lube disch. oil temp.	37 °C	77 °C	No trip
13.	Journal brg. Metal temp.	55 ~ 65 °C	107 °C	113 °C
14.	Thrust brg. Metal temp.	48 ~ 53 °C	99 °C	107 °C
15.	Lube oil tank pressure	- 70 ~ -150 mm WC		
16.	Lube oil tank level		<u>High lvl alarm:</u> 1375.5 mm <u>Low lvl alarm:</u> 1175.5 mm	
17.	Thrust bearing wear	0.4 mm	0.9 mm	1.0 mm + Thrust side -Anti thrust side (2 out of 3)
18.	Vibration for the 4 bearings	<0.075 mm PP	0.125 mm PP	0.25 mm PP
19.	Rotor eccentricity up to 600 rpm	Below 0.05mm		0.075 mm
20.	Differential expansion	0.0 mm	-7.0 mm rotor short + 3.0 mm rotor long	- 7.8 mm rotor short + 3.8 mm rotor long
21.	HP & IP upper & lower Casing difference	Nil	42 °C	56 °C
22.	Casing metal diff. Temp		77 °C	No trip
23.	LP gland steam temp.	Set value 150 °C	170 °C	No trip
24.	Gland steam pressure	0.5 bar		No trip
25.	Brg. Oil temp. control abnormal	36 ~ 38 °C	55 °C	No trip
26.	Rupture diaphragm			1.3 bar (a)
27.	Exhaust hood temp.	70 °C set temp. for control	80 °C	120 °C
28.	MOP	22~27 bar (g)		
29.	TOP	2.8~3.7 bar (g)		
30.	EOP	2.7~3.7 bar (g)	0.5 kg/cm2 (g)	
31.	Auto stop oil pressure.	8.5 ~ 10.0 bar (g)		2.9 bar
32.	HP control oil pr		3.0 kg/cm2 (g)	6.0 kg/cm2 (g)
33.	Protective device oil pr. (OST)			10.0 bar (g)



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Sr. No.	Description	Normal	Alarm	Trip
34.	Brg. Drain oil temp.		77 <sup>0</sup> C	No trip
35.	Electrical over speed trip			3328 rpm 2 of 3 switches
36.	Mechanical over speed			3300 rpm
37.	ST control system failure	N.A	N.A	Trip
38.	Flange / bolt temp. Diff.	Nil	+ 110 <sup>0</sup> C, - 30 <sup>0</sup> C	No trip
39.	HP & IP C. V. inner / outer metal diff. Temp.	Nil	HP: 190 <sup>0</sup> C  IP: ± 83 <sup>0</sup> C	

## **10.0 Do's & Don'ts**

- **Do's:**
  - All interlocks & protections to be checked before rolling.
  - Test safety controls and devices on a periodic basis.
  - Ensure turbine operators are adequately trained to assure safe and efficient operation.
  - Inspect the turbine and associated auxiliaries daily for proper operation, and/or adverse conditions.
  - Maintain a log of incidents that effect turbine operation.
  - Allow only authorized person to work and attend any leakages.
  - Ensure proper housekeeping & adequate area lighting.
  - Inform field engineer before charging any high pressure lines.
  - Check for abnormal sound, vibrations and temperature from all equipment.
  
- **Don'ts**
  - Avoid operating turbine with abnormal conditions like oil/steam leakage or sound.
  - Avoid bypassing interlocks and permissive of associated auxiliaries.
  - Permit unqualified personnel to operate.
  - Ever leave the turbine and generator unattended for long periods of time.

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### **11.0 ABBREVIATIONS / NOTATIONS:-**

- SOP: Standard Operating Procedure
- UCE: Unit Control Engineer
- DE: Desk Engineer
- FE: Field Engineer
- DCS: Distributed Control System
- EE: Electrical Shift Engine